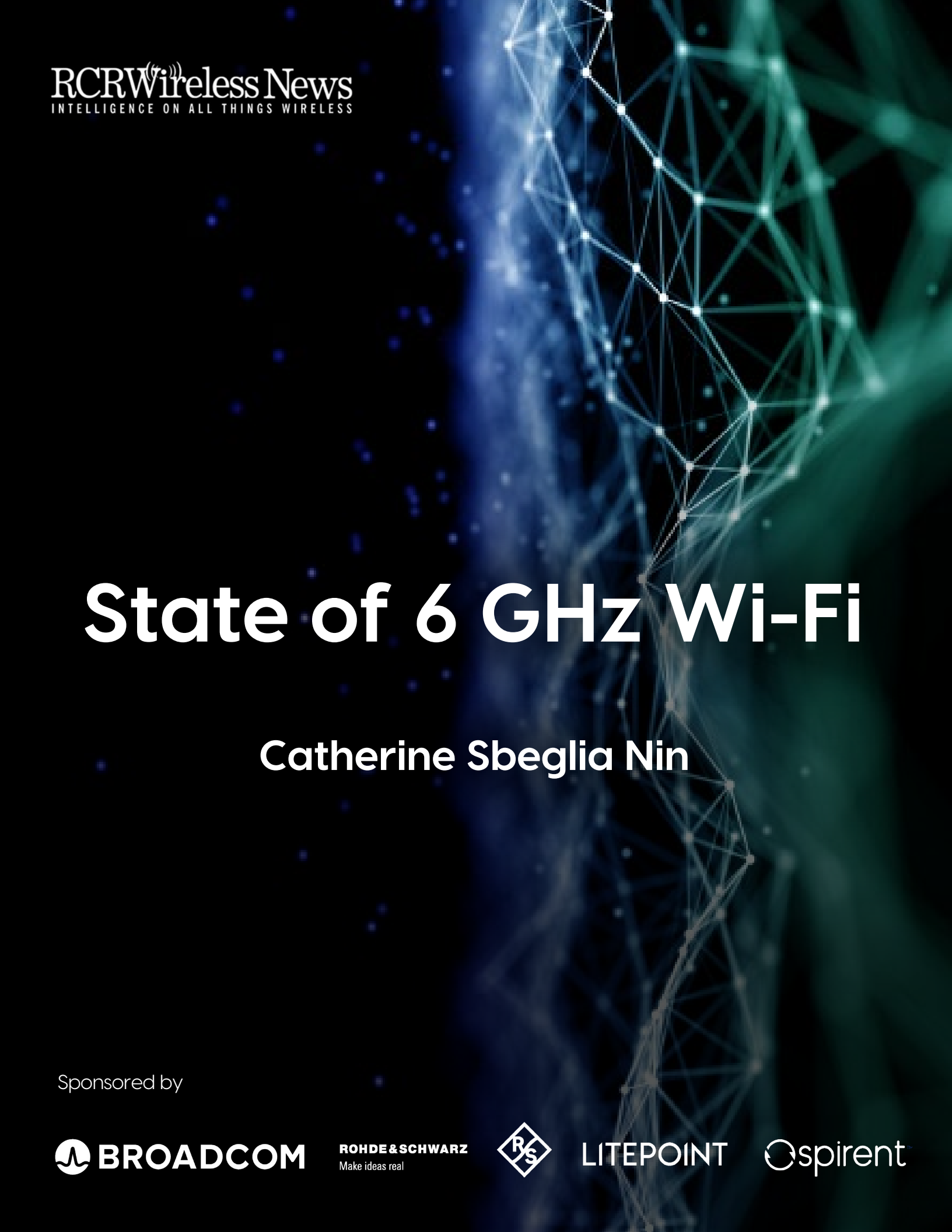
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State of 6 GHz Wi-Fi
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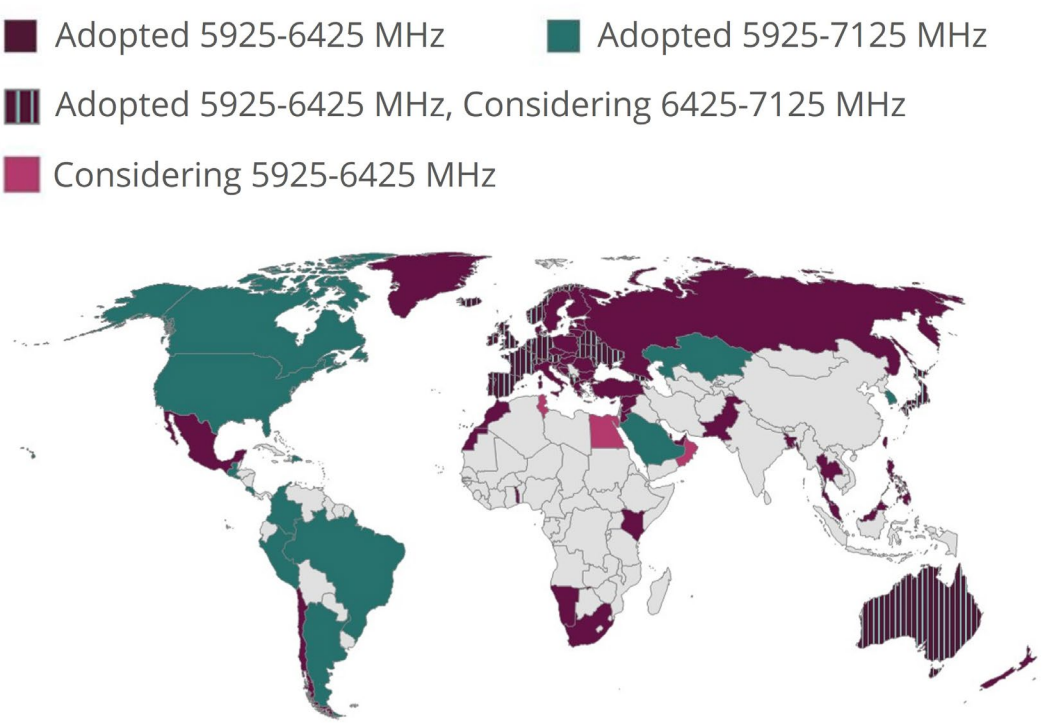
2024 – A YEAR OF ENTHUSIASM FOR WI-FI

Looking back on 2024 reveals a material rise in confidence and enthusiasm around Wi-Fi, particularly when it comes to the new features introduced in the Wi-Fi 7 standard, or IEEE 802.11be. Many of these features rely on access to the 6 GHz band, which not every country has or will ever have — this report will touch on that, diving into the global state of Wi-Fi spectrum.

It will also detail the key features enabling the improved multi-user experience first promised in Wi-Fi 6, but we have yet to see. We will explore what makes these features so exciting, but also the challenges they have brought to those responsible for testing that they work. And finally, to fully contextualize the outlook for Wi-Fi 7, we also check in on Wi-Fi 6E and provide a glimpse into what may be expected from Wi-Fi 8, even with certification still years away.

Generation	IEEE standard	Adopted	Radio Frequency (GHz)
(Wi-Fi 0)	802.11	1997	2.4
(Wi-Fi 1)	802.11b	1999	2.4
(Wi-Fi 2)	802.11a	1999	5
(Wi-Fi 3)	802.11g	2003	2.4
Wi-Fi 4	802.11n	2009	2.4, 5
Wi-Fi 5	802.11ac	2013	5
Wi-Fi 6 / Wifi 6E	802.11ax	2021	2.4, 5, 6 / 2.4, 5, 6
Wi-Fi 7	802.11be	2024	2.4, 5, 6
Wi-Fi 8	802.11be	exp. 2028	2.4, 5, 6



(Image courtesy of Wi-Fi Alliance)

STATE OF GLOBAL 6 GHZ WI-FI ADOPTION

Sixty-two countries have designated at least some of the 6 GHz band for Wi-Fi use, according to the Wi-Fi Alliance

The U.S. Federal Communications Commission (FCC) officially opened up the 6 GHz band for unlicensed Wi-Fi use in April 2020, resulting in the introduction of Wi-Fi 6E, and in turn, faster speeds and increased capacity. With this decision, an additional 1,200 megahertz of spectrum is now available for unlicensed Wi-Fi use. While the United States was quick to adopt all of the band (5925-7125 MHz) for Wi-Fi use, the response from the rest of the world varied greatly.

In fact, when claims of global consensus on mid-band spectrum harmonization were made following December 2023's World Radio Conference (WRC-23), Broadcom's Director of Technology Strategy Christopher Szymanski told *RCR Wireless News* pushed back, citing the variance in portions of spectrum identified and the conditions in which the spectrum was allocated.

"It's been a year since the WRC conference where certain regions were exploring IMT identification, with the GSMA saying this is necessary for the future of 5G-Advanced and 6G and the Wi-Fi industry saying it's necessary for the future of Wi-Fi," said Szymanski. But it seems that even in the short time since the conference, Wi-Fi has gained some ground in this fight.

Today, 13 countries have adopted the full 5925-7125 MHz range, according to the Wi-Fi Alliance, while 50 others have already allocated a portion of the band for Wi-Fi. Further, many countries are still considering opening up the band or opening up more of the band, like the United Kingdom, which has, thus far, only opened up 5945-6425 MHz for Wi-Fi use.

6 GHz in EMEA

Europe, the Middle East and Africa (EMEA) came out of WRC having identified 6425-7125 MHz for International Mobile Telecommunications (IMT), noting that this band is also used for deployment of RLANs (e.g., Wi-Fi).

Much of the discussion around the need for 6 GHz IMT has been driven out of EMEA. In fact, the UAE has just announced the allocation of 6425-7125 MHz to its two operators for IMT use. "This appears to be premature," stated Szymanski. "There is no market yet for 6 GHz IMT. There is no user equipment in the market that could take advantage of such an allocation. It's unlikely that other countries will allocate the entire upper 6 GHz for IMT, which would leave the UAE in a position where they've gotten way ahead of the global market."

6 GHz in Europe

Europe, he said, is "neck deep" in technical studies. "And it looks like Wi-Fi access to at least part of the upper 6 GHz in Europe will be granted on a shared basis with IMT, or as an extension of the lower 6 GHz rules. I see no scenario in Europe in which Wi-Fi will not have meaningful access to more spectrum in the upper 6 GHz band," he continued, adding that much of the current discussion in Europe is around the technical conditions that would allow IMT and Wi-Fi to operate in the same spectrum.

6 GHz in the Americas

Brazil and Mexico were the only two countries in the Americas to leave the WRC with IMT designations in the 6 GHz band. Specifically, they both reserved the 6425-7125 MHz range for IMT identification. ndeed, Brazil's Agência Nacional de Telecomunicações (ANATEL) in June confirmed proposed updates that would restrict Wi-Fi 6 GHz band from the current range of 5925-7125 MHz to a narrower band of 5925-6425 MHz for this plan.

6 GHz in APAC

At the WRC's conclusion, the Asia–Pacific (APAC) region was given the 7025-7125 MHz band as their IMT allocation (Cambodia, Laos and Maldives were exceptions and received the full 6425-7125 GHz band for IMT).

Since then, though, Kazakhstan stands out as it has chosen to adopt the full 5925-7125 MHz range. "I know it's a smaller country, but their GDP per capita is higher than China and Russia," Szymanski commented, noting that despite Kazakhstan's close relationship with these two, much bigger countries, neither of them are planning to adopt 6 GHz for Wi-Fi. However, for Broadcom, this development in Kazakhstan signals true momentum for 6 GHz Wi-Fi in the Asia–Pacific (APAC) region.

CHRISTOPHER SZYMANSKI,
Director of Technology Strategy
Broadcom

"I see no scenario in Europe in which Wi-Fi will not have meaningful access to more spectrum in the upper 6 GHz band."

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6 GHZ DEVICE MOMENTUM

IDC found that momentum around 6 GHz devices — which means 6E and 7 devices — to be strong, with the firm predicting that 2024 would see 807.5 million shipments, up 66% from 2023. The firm also expects that 147.2 million Wi-Fi 6E access points (APs) and 23.12 million Wi-Fi 7 APs shipped last year. When it comes to Wi-Fi 7 specifically, IDC said 231.4 million device shipments are expected to have shipped in 2024, accounting for 5.7% of all Wi-Fi device shipments.

"The increasing user demand for reliable connectivity is not slowing down, and Wi-Fi will continue to support complex use cases across automotive, IoT, and XR in 2024 and beyond. Wi-Fi 6 enabled devices (including Wi-Fi 6E) will maintain their stronghold on IoT this year with over 47 million shipments. XR is expected to see more than 24 million Wi-Fi 6 devices shipped, and automotive is forecast to see more than 21 million Wi-Fi 6 devices shipped in 2024," said the Wi-Fi Alliance, citing data from ABI Research.

The Wi-Fi Alliance noted as well that the advanced applications mentioned above depend on the capabilities of 6 GHz Wi-Fi. For instance, Wi-Fi 7's support of 320 megahertz (MHz) channels, double the 160 MHz of Wi-Fi 6E, has long been a headlining feature, delivering unprecedented reliability and range while offering gigabit-plus performance. But it also requires the availability of the 6 GHz band.

Szymanski highlighted the importance of 320 MHz channels and of a three-channel minimum per market for Wi-Fi. He further maintained that for those committed to some IMT identification for the 6 GHz band, spectrum will be needed from somewhere else for Wi-Fi. "The market is the market," he said, referring to the very real need for more unlicensed Wi-Fi spectrum. "So, if they can only give us two bands, where's the other 320 megahertz going to come from?

"Despite the lack of global harmonization around 6 GHz allocation, Gabriel Desjardins, director of product marketing in Broadcom's Wireless Connectivity Division, told *RCR Wireless News* that early 320 MHz adoption does indeed indicate that this capability will be "mainstream" in Wi-Fi 7 and 8.

"Virtually every Access Point has 320 MHz support in the 6 GHz band and a high percentage of phones and PCs support 320 MHz," Desjardins said. He noted that handset volumes on the market are split right now between 160 and 320 MHz, but "we believe the market is moving entirely to 320 MHz in the near future," he added. And Desjardins expects similar penetration for the Access Point market, as the benefit there is also apparent: "Basically, at every point in your home, you're going to get higher throughput with a Wi-Fi 7 AP than with 6E or 6," he said.

(Image courtesy of Apple Inc.)

Wi-Fi 7 handsets, as of October 2024:

1. Asus ROG Phone 7
2. Asus ROG Phone 8 Pro
3. Asus Zenfone 10
4. Asus Zenfone 11 Ultra
5. Google Pixel 8
6. Google Pixel 8 Pro
7. Google Pixel 9
8. Google Pixel 9 Pro
9. Google Pixel 9 Pro Fold
10. Google Pixel 9 Pro XL
11. iPhone 16
12. iPhone 16 Plus
13. iPhone 16 Pro
14. iPhone 16 Pro Max
15. Motorola Edge 50 Ultra
16. Motorola Edge+
17. Motorola Razr (2024)
18. Motorola Razr+ (2024)
19. Nubia Z50S Pro
20. OnePlus 12
21. OnePlus 12R
22. OnePlus Ace 3
23. OnePlus Open
24. Samsung Galaxy S23 Ultra (not yet enabled)
25. Samsung Galaxy S24 Ultra
26. Samsung Galaxy Z Fold 5 (not yet enabled)
27. Vivo X Fold3
28. Vivo X Fold3 Pro
29. Vivo X100
30. Vivo X100 Pro
31. ZTE nubia Red Magic 9 Pro
32. ZTE nubia Red Magic 9 Pro+
33. ZTE nubia Z60 Ultra

PLAYING NICE IN THE 6 GHZ BAND – AN AFC UPDATE

In order for unlicensed Wi-Fi 7 devices to play nice in the 6 GHz band with the licensed users already occupying that band, the FCC established Automated Frequency Coordination (AFC), a spectrum use coordination system designed specifically for 6 GHz operation that resembles similar systems in place such as the one that supports CBRS wireless operation.

Because the 6 GHz band was already occupied by incumbent users, such as fixed satellite providers, the FCC imposed pretty significant restrictions on the Wi-Fi devices looking to transmit in this band. More specifically, to avoid potential interference with existing 6 GHz incumbents, the FCC defined two types of device classifications with different transmit power rules for Wi-Fi devices operating on the band: low power access points (APs) for indoor Wi-Fi and standard power APs that can be used indoors and outdoors.

Standard power APs, particularly when used outdoors, are the most likely to interfere with existing 6 GHz users in the area, and therefore, AFC will prove most valuable in outdoor scenarios.

The Open AFC Group, operated by the Telecom Infra Project (TIP), works on software that will provide the flexibility for outdoor deployments of next-generation Wi-Fi. In pursuit of its goal to develop an open-source reference implementation of an AFC system, the group recently partnered with the Wireless Broadband Alliance (WBA) to drive global adoption of Wi-Fi in the new 6 GHz unlicensed band because using the 6 GHz band — whether all or some of it — for unlicensed Wi-Fi is a government-by-government decision. The below map and table from the Wi-Fi Alliance provides an update on where global AFC adoption stands.

Regulations enabling 6 GHz Standard Power Wi-Fi Devices Under Control of Automated Frequency Coordination (AFC) System

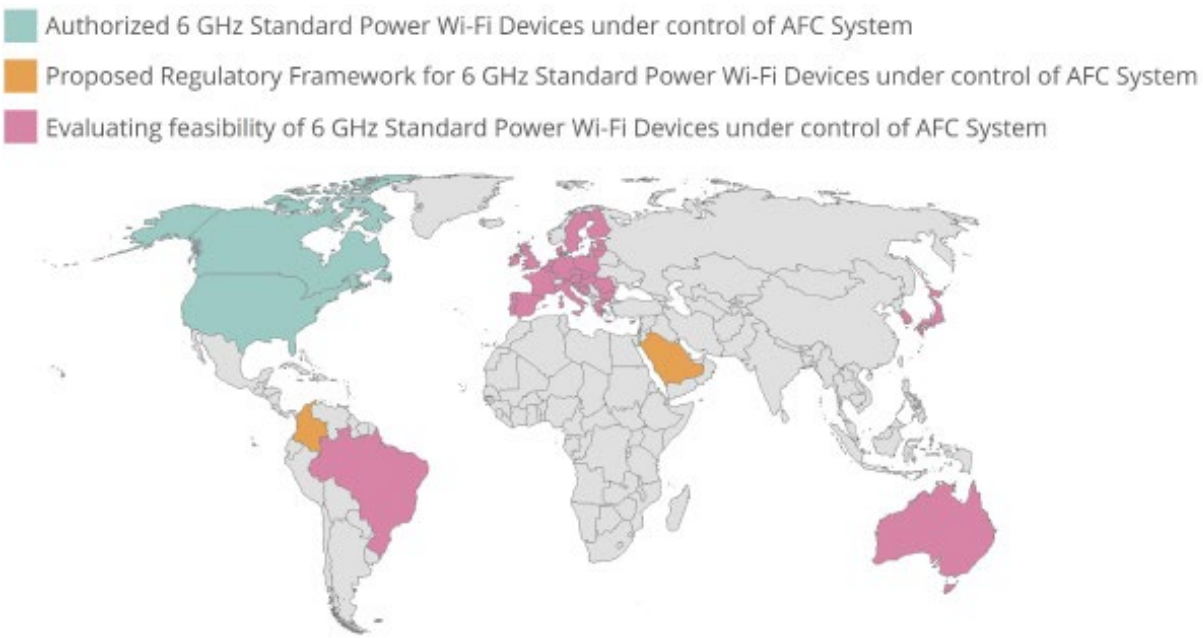
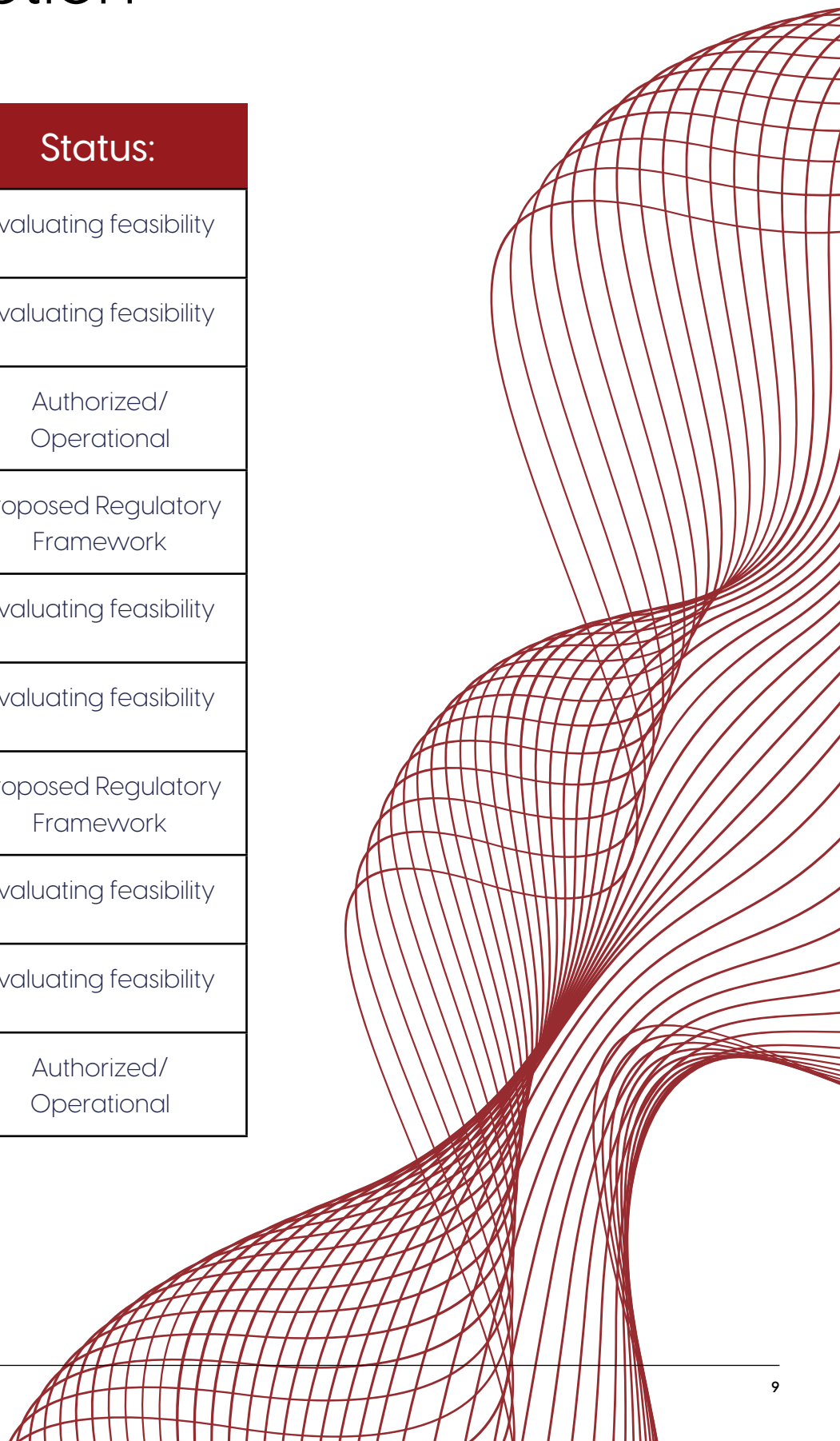


Image courtesy of Wi-Fi Alliance

State of Global AFC Adoption

Country:	Status:
Australia	Evaluating feasibility
Brazil	Evaluating feasibility
Canada	Authorized/ Operational
Colombia	Proposed Regulatory Framework
European Union	Evaluating feasibility
Japan	Evaluating feasibility
Saudi Arabia	Proposed Regulatory Framework
South Korea	Evaluating feasibility
United Kingdom	Evaluating feasibility
United States	Authorized/ Operational

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'FEATURE-RICH' WI-FI 7 TESTS T&M EQUIPMENT

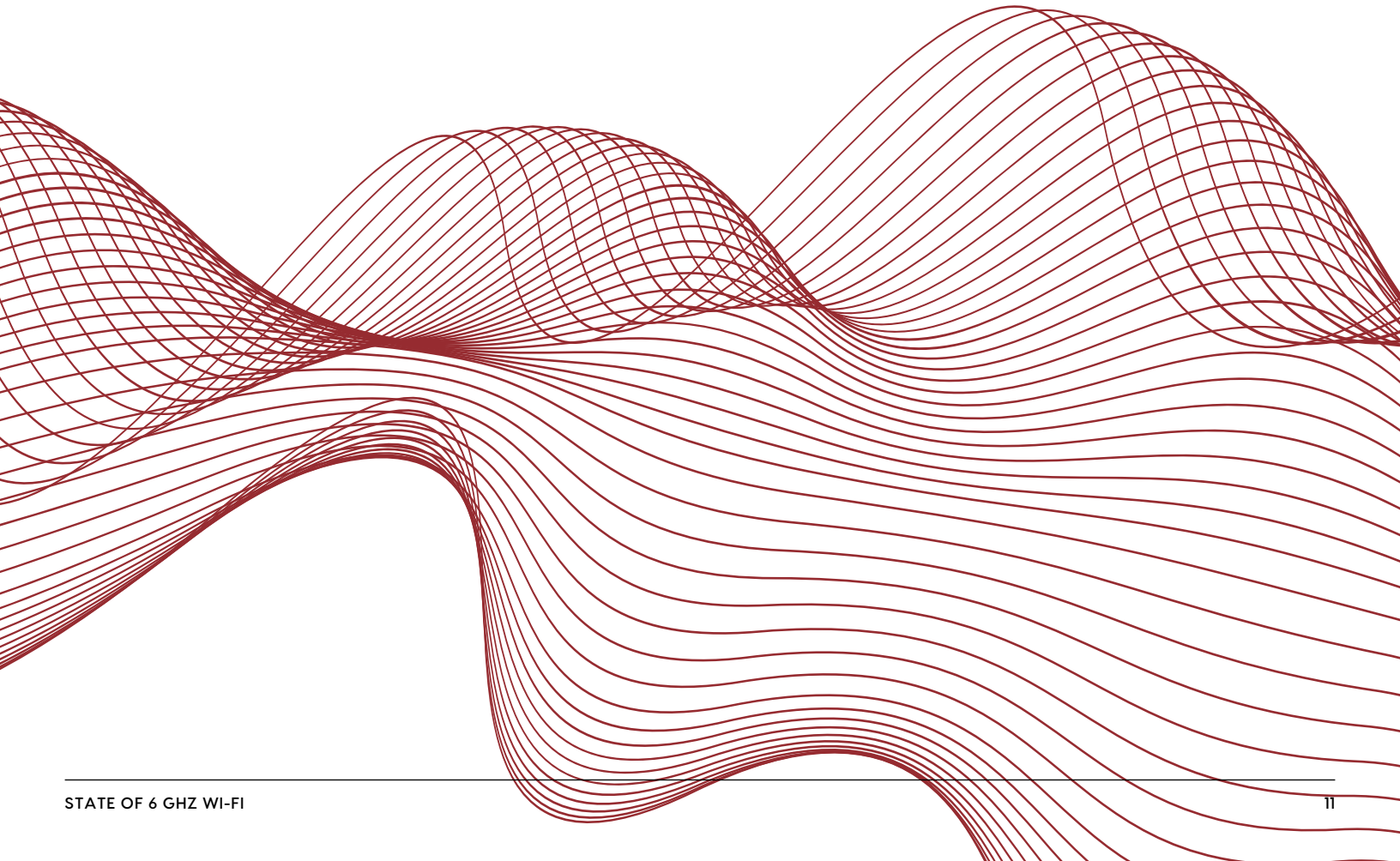
Beyond being built from the group up with the 6 GHz band in mind, Wi-Fi 7, according to LitePoint's Product Marketing Manager Khushboo Kalyani, is notably "feature-rich" compared to previous generations. "Wi-Fi 7 took a really big stride in terms of the number of features it added," she said, explaining that several functionalities and features that were originally part of 11.ax were not really implemented or were optional, but are now coming into play. And that's exciting, she said. "But from a test perspective, it requires a lot of these features to be tested. It adds to the number of test combinations you can do, especially from an R&D perspective," she stated.

First, here are a few of the standout features in the Wi-Fi 7 standard:

Multi-Link Operation (MLO). With MLO, a device connected in the 5 GHz band that is suffering from degraded performance due to another device popping up on the network will automatically — and very quickly — switch over to the 6 GHz band.

Preamble puncturing. This feature — optional in Wi-Fi 6 but now part of the Wi- Fi 7 standard — improves spectral efficiency by allowing an AP to transmit a "punctured" portion of the spectrum channel if some of the channel is being used by legacy users by carving out the thin slice that has interference on it. The result is wider channels even when interference is present. It also offers those countries that have not enabled access to the continuous 320 megahertz of available 6 GHz spectrum to achieve wider channels for better transmission.

4096-QAM or 4K QAM. This feature boosts the peak rates to increase throughput and capacity compared to Wi-Fi systems using 1K QAM modulation. More specifically, it has been suggested that 4K QAM can increase the physical layer (PHY) data rate by 20% and improve modulation accuracy.



When considered together, these advanced features offer better reliability for the end user; but they also present a challenge for test and measurement companies. "Features like puncturing and MLO tend to make the whole thing much more complicated," confirmed Joerg Koepp, Market Segment Manager of IoT at Rohde & Schwarz. "First of all, you have more combinations you have to test because you have more variants," he said, pointing, as an example, to the different regulatory requirements related to 6 GHz Wi-Fi use across different countries.

"Multi-Link Operation introduces a paradigm shift because as the interface patterns evolve around as you move — closer and further — the way you combine these two physical channels changes, so testing for those changes becomes important. For test equipment, this introduces changes and new reporting needs," agreed Janne Linkola, Principal Product Manager of Spirent's Automated Test & Assurance business unit. He said that Spirent has put a great deal of effort into to showing the exact multi-link configuration a customer is currently using and then report it as a function of time so that they can see when the switch between bands happens.

About 4K QAM, specifically, Linkola said, "The problem is that the modulation rate is now so high and requires such a signal to noise ratio that it is actually relatively difficult to build test beds that still work well." As a result, the test and measurement company has had to "rebuild" its products "basically from the ground up" to capture this and other Wi-Fi 7 features.

"Having put all of this together, it's a lot of test items and combinations to be testing, so we've seen the need for a test automation tool growing quite a bit because… customers are looking for a really polished automation tool that can be edited easily and has chipset-specific support," said Kalyani.

JANNE LINKOLA,
Principal Product Manager
Spirent

"Multi-Link Operation introduces a paradigm shift because as the interface patterns evolve around as you move – closer and further – the way you combine these two physical channels changes, so testing for those changes becomes important."

There is another looming obstacle introduced by the fact that Wi-Fi 7 is so feature intensive. During a conversation for last year's Wi-Fi report, Broadcom told *RCR Wireless News* that power consumption is another trend and challenge worth following for those deploying Wi-Fi solutions, and that the chip maker is focused on providing lower-power modes in its products. This year, Koepp reiterated this concern, stating that all of these features outlined above all have additional power consumption associated with them. "At the end of the day, they need more power and [devices] are becoming hotter and hotter and this is not what we want, especially in this world where everyone is talking about sustainability," he said. "This is a design challenge our customers have."

In the Wi-Fi 6 standard, "target wake time" (TWT) was introduced. This feature can tell the device exactly when to put its Wi-Fi radio to sleep and exactly when to wake it up to receive the next transmission as long as the device is connected to the Wi-Fi access point, conserving power, and resulting in longer battery life. Wi-Fi 7 builds off of that with the introduction of Restricted Target Wake Time (RTWT), which enables devices to negotiate specific times of transmission to better handle latency-sensitive traffic. "The Wi-Fi 7 restricted TWT extends capabilities to provide reservation mechanisms for more predictable latency and generally higher reliability for latency-sensitive traffic," Spirent explained in a white paper.

JOERG KOEPP,
Principal Product Manager
Rohde & Schwarz

At the end of the day, [new Wi-Fi 7 features] need more power and [devices] are becoming hotter and hotter and this is not what we want, especially in this world where everyone is talking about sustainability."

(Image courtesy of 123RF)

WI-FI 7 ADOPTION TO SPUR ENTERPRISE WI-FI MARKET RECOVERY, SAYS DELL'ORO GROUP

A recent report from Dell'Oro Group found that enterprise class Wireless LAN (WLAN) revenues increased quarter-over-quarter for the second time in a row, hitting $2.3 B in 3Q 2024. The firm also noted continued growth in Wi-Fi 7 adoption, with shipments increasing 69% compared to Q2 2024. "In 3Q 2024, the worldwide WLAN market performed better than it has in a year," said Siân Morgan, research Director at Dell'Oro Group. She called the recovery "gradual," but said Dell'Oro is expecting "significant" year-over-year WLAN revenues growth in 4Q 2024.

"The adoption of Wi-Fi 7 is material and will keep growing in 2025, once all major vendors are recognizing revenues from the products that have been announced. In 2025, we expect that nearly 40% of manufacturers' Indoor AP revenues will come from Wi-Fi 7," continued Morgan.

Dell'Oro also found that Huawei remained the forerunner in Wi-Fi 7 shipments but noted that this lead is shrinking as other vendors gain momentum. The firm also predicted that 2025 will see new AI-Ops features for WLAN be announced, contributing further to recurring software revenue growth.

The latest Wireless Broadband Alliance (WBA) Industry Report, which interviewed 170 industry executives around the world, supported this growing interest in Wi-Fi 7 in enterprise scenarios. The report found that 37% had deployed Wi-Fi 6E, with 19% stating they had deployed the latest Wi-Fi 7 standard, despite it being a new technology.

SMARTPHONE TRAFFIC IS 'OVERWHELMINGLY' OFFLOADED TO WI-FI

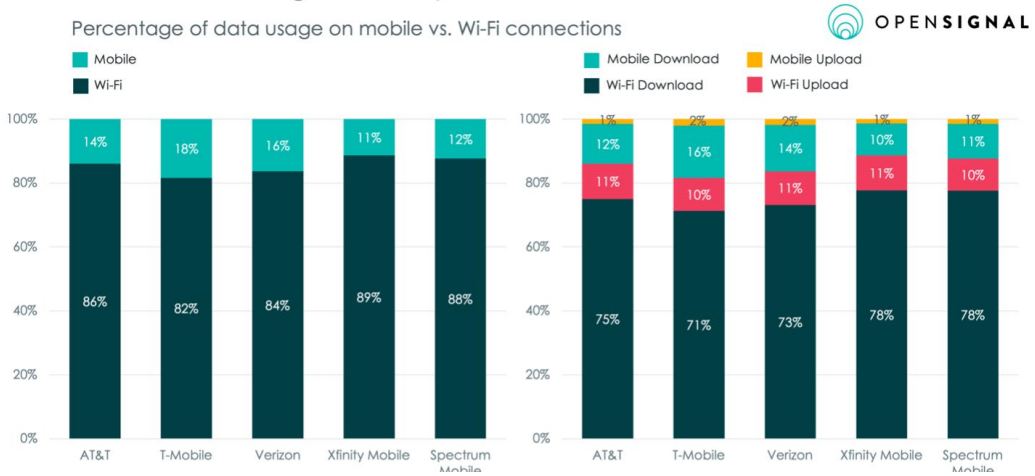
OpenSignal found that smartphone users spend 77% to 88% of their screen-on time connected to Wi-Fi

OpenSignal recently found that the "brunt" of phone data usage across five mobile service providers — three Mobile Network Operators (MNOs) Verizon, T-Mobile, AT&T and Mobile Virtual Network Operators (MVNOs) Spectrum Mobile and Xfinity Mobile — is "shouldered" by Wi-Fi networks.

"Our research shows that Wi-Fi networks shoulder the brunt of our users' phone data usage, with traffic being overwhelmingly offloaded from mobile networks to Wi-Fi," wrote OpenSignal report authors Rupert Bapty and Andrey Popov. The pair further noted that the majority of time spent browsing on smartphones occurs while connected to Wi-Fi.

OpenSignal found that there is "a small but clear difference" between the three MNOs and the two cable MVNOs. Proportionally, users consume more data over Wi-Fi on the two MVNO networks, with Xfinity Mobile having the highest proportion of data consumption on Wi-Fi at 89% of their total. But the others didn't look much different: For Verizon users, 84% of data consumption happened over Wi-Fi; for AT&T, it was 86%; and for T-Mobile US, it was 82%.

Mobile users use significantly more data over Wi-Fi connections



Source: OpenSignal

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This may be due in part to the fact that most of Americans' smartphone usage occurs at home. According to OpenSignal's findings, users are spending about three times more of their screen-on time at home than away, regardless of their network.

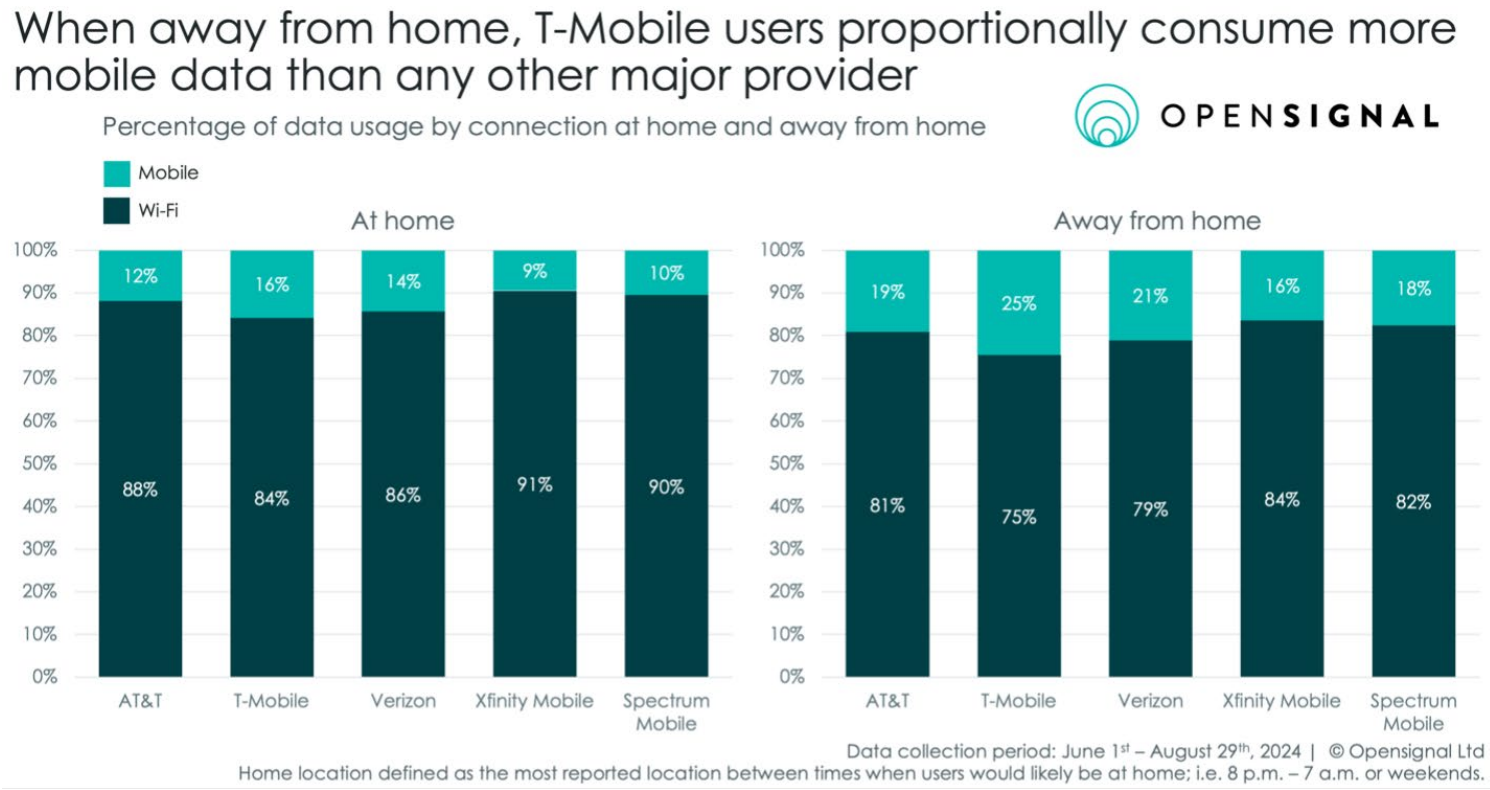
However, the pattern of using Wi-Fi more often than cellular held true outside of the home, as well. For AT&T, for instance, 81% of data was still consumed over a Wi-Fi network. For T-Mobile, this number was 75% and for Verizon, it came in at 79%. Notably, Xfinity Mobile users rely on Wi-Fi the most, with only 16% of their data usage occurring over a mobile connection. Bapty and Andrey Popov added, too, that users spend 77% to 88% of their screen-on time connected to Wi-Fi.

"Users are likely to connect to Wi-Fi at home and at work to benefit from better indoor signal and increased speeds. When outside, users are more likely to use less data-hungry apps such as navigation, music or podcasts," they wrote. "While most U.S. mobile subscribers are on unlimited plans, there are still a significant number of customers on data-capped plans, especially at the cable MVNOs. This creates an end-user incentive to switch to Wi-Fi where available."

While these results may not be what mobile operators want to hear amid ongoing spectrum disputes between the cellular and Wi-Fi communities, the reality is that Wi-Fi offloading is a key strategy to redirect data traffic from congested licensed spectrum to available unlicensed spectrum. In addition to addressing network congestion, Nadeem Akhtar, vice president of product line management at HFCL Ltd., said it can also help operators tackle spectrum scarcity and cost, as well as lower infrastructure costs.

"Mobile data offloading is rapidly becoming a cornerstone of network management strategies for telecom operators worldwide," wrote Akhtar. "This approach offers significant benefits in spectrum optimization and cost savings. By offloading up to 65% of the total traffic to Wi-Fi networks1, carriers can dramatically increase the efficiency of their licensed spectrum usage, allowing them to serve more customers without acquiring additional expensive spectrum licenses … Furthermore, mobile data offloading enhances customer experience through seamless handovers between cellular and Wi-Fi networks, ensuring consistent service quality even in traditionally congested areas. This leads to higher customer satisfaction and potentially reduced churn."

He added, as well, that Wi-Fi offloading may also lead to new use cases and paths to revenue, and said that emerging technologies like Wi-Fi 7, Open Roaming and AI-driven optimizations will further enhance Wi-Fi offload capabilities.



WBA OpenRoaming coverage map (source the Wireless Broadband Alliance)

'EVERY DAY THERE ARE NEW NETWORKS' – A WI-FI OPEN ROAMING ADOPTION UPDATE

According to the WBA Industry Report 2025, 81% of the 170 respondents are planning to deploy OpenRoaming. Of those, 25% were already rolling out the technology, 42% said they would deploy in 2025, with 27% planning for 2026.

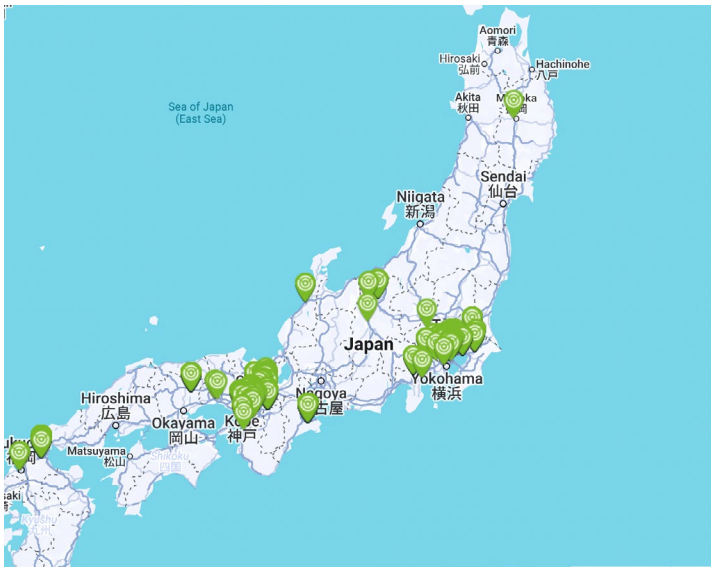
The relatively new technology, developed by Cisco and built upon a set of standards and guidelines developed by the WBA and Wi-Fi Alliance, allows seamless and secure Wi-Fi onboarding. A user can join any network managed by any provider within the established trusted federation of providers. The network is then able to automatically authenticate devices by using established identity providers, such as a service provider, device manufacturer, cloud ID or even loyalty memberships.

When asked why they are interested in deploying or investing in OpenRoaming or Passpoint compliant networks, Industry Report 44% of the respondents said to enable seamless access between Wi-Fi and 5G/LTE, while 43% said to provide improved security on Wi-Fi (43%). These top answers were followed by enabling frictionless access to Wi-Fi (39%) and enabling seamless access across different networks (38%).

OpenRoaming is currently on Release 4 of the technology, launched in October. One of the most notable enhancements is the ability to use OpenRoaming on moving platforms like trains, planes and ships.

When discussing the technology's progress further with *RCR Wireless News*, WBA CEO Tiago Rodrigues, pulled up an online OpenRoaming global coverage map to highlight those countries and cities that are outpacing the others in terms of adoption. "The U.S is getting a good start; in Europe, we are starting to see some countries like Belgium … looking okay. London is starting to get some traction, as well. Another country that is very well layered is Japan," he said. "OpenRoaming is all about security and the user experience. We are super enthusiastic to see that every day there are new networks. Let's be honest, this is the start. Like any technology, you need a starting point, and I believe we will continue to grow over time."

So, with adoption marching along at a good clip, it's time to think about the next phase of OpenRoaming, and according to Rodrigues that's OpenRoaming for IoT, particularly for those devices without a user interface. "Like a speaker or earbuds, or even a microwave," he clarified. Using OpenRoaming, these types of devices can simply connect to a Wi-Fi network as soon as it enters the coverage area. "This can be on an enterprise or residential level. One example is I have a factory where I've deployed OpenRoaming, so I am broadcasting a specific code that only the devices can see. Any IoT devices with the same code, as soon as it enters the coverage of Wi-Fi, will attach automatically," continued Rodrigues, adding that the same goes for a residential scenario. There is no configuration necessary, no inputting that silly network name you came up with five years ago or a long, complicated password just to get your new smart thermostat up and running.



(source: the Wireless Broadband Alliance)

(source: the Wireless Broadband Alliance)

WHAT TO EXPECT FROM WI-FI 8

Though certification for Wi-Fi 8, or 802.11bn, is not expected until 2028, vendors and standards bodies are already formulating plans around what Wi-Fi 8 will be and what features will be included. In the same way that Wi-Fi has been dubbed Extremely High Throughput (EHT), Wi-Fi 8 is being called Ultra High Reliability (UHR) and is expected to be aimed at industrial applications.

"Wi-Fi 8, from what we understand pre-spec, is more of an incremental change rather than a completely new tech standard," said Kalyani. "Unlike previous generations that have almost always focused on higher throughput and user density, Wi-Fi 8 focuses on reliability and ensuring some level of determinism." In fact, she pointed out that no new spectrum is being added for Wi-Fi 8 and nothing beyond 4096 QAM modulation is being considered, so in terms of throughput, we're talking about the same theoretical throughput of Wi-Fi 7.

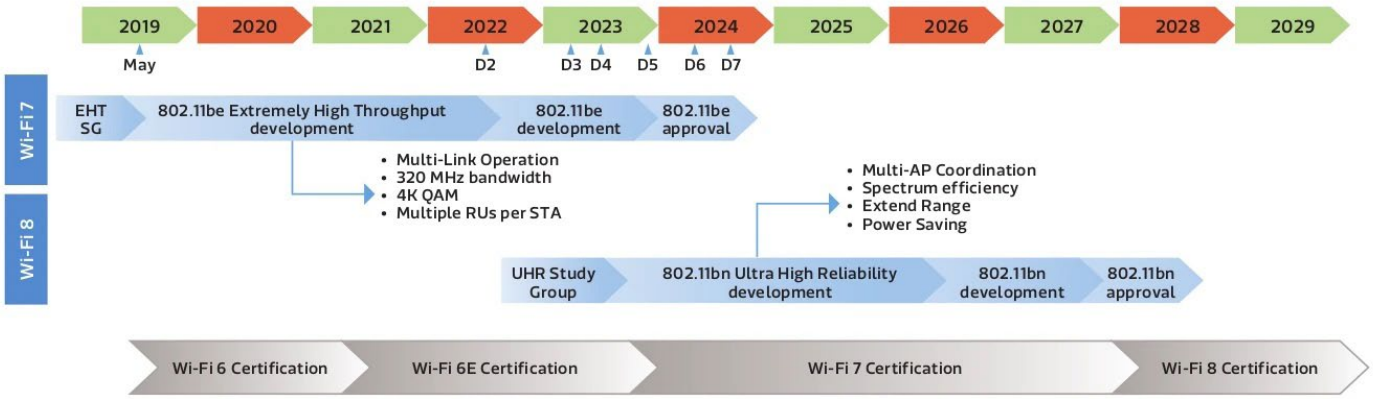
KHUSHBOO KALYANI,
Product Marketing Manager
LitePoint

"Unlike previous generations that have almost always focused on higher throughput and user density, Wi-Fi 8 focuses on reliability and ensuring some level of determinism."

Instead, it's about improving spectrum efficiency and utilization, or as Koepp put it "tuning the physical layer to make it more reliable." The "cornerstones" of Wi-Fi like additional bandwidth and spectrum have already been obtained in Wi-Fi 7, he added.

In service of these goals, a few key Wi-Fi 8 topics have emerged: the proposed use of millimeter wave (mmWave) links to deliver higher bandwidth and data rates; the inclusion of Multi-Access Point Coordination (MAPC), which builds upon the network management improvements of previou generations of Wi-Fi; and ambient power technology designed to improve energy efficiency.

These three areas are explored in more detail below.



Source: IEEE

Figure 4. IEEE and WFA milestone about Wi-Fi 7 and Wi-Fi 8.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mmWave in Wi-fi 8 – the promise and the problem

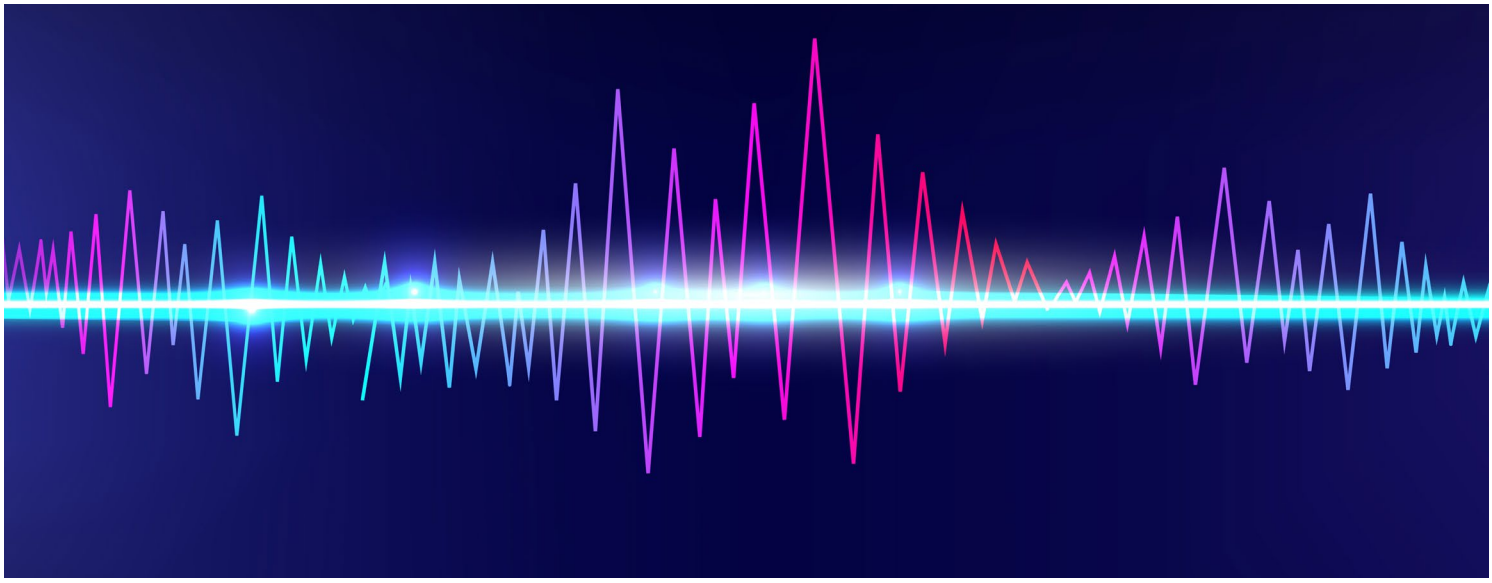
Some claim that the use of mmWave in Wi-Fi 8 will support data rates of up to 100 Gbps. A research paper called Wi-Fi 8: Embracing the Millimeter-Wave Era stated that the incorporation of mmWave bands in Wi-Fi 8 is a "natural progression" in order to enable advanced use cases like virtual and augmented reality.

"The most important benefit of mmWave is high throughput and low latency. In addition, high frequency communication will naturally reduce the delay of each communication and allow for a substantial increase in frequency division multiplexing. In this way, each link can individually use a portion of the spectrum without interfering with each other and QoS is guaranteed in very dense environments. mmWave will also address the lack of 6 GHz band for Wi-Fi in some countries, providing a strong lighthouse client feature and solutions for the development of integrated communications and sensing," the paper continued.

In addition, mmWave is expected to improve the performance of Wi-Fi high-node density environments like stadiums and other large venues.

While the use of this high-frequency band in the next generation of wireless technology is exciting and has the potential to deliver on the promise of higher bandwidth and throughout, implementing mmWave under current sub-7 GHz protocols and with today's hardware won't be particularly easy. Hardware impairments and incompatibles are expected, and therefore, testing and validation will prove absolutely critical as vendors develop their Wi-Fi 8 products and solutions.

The challenges, however, appear to be more than worth it, according to Liu, X., Et al: "The significance of this technology could lead to a unique certification, potentially known as Wi-Fi 8E, emphasizing the crucial role of mmWave technology in the future of wireless communication," the paper stated.



(Image courtesy of 123RF)

What is MAPC?

One of the major features expected to make it into the standard is Multi-Access Point Coordination (MAPC), which builds upon the network management improvements of previous generations of Wi-Fi.

MAPC refers to the management of multiple access points in a wireless network to avoid interference and ensure efficient communication between the client devices and the network. Wi-Fi 6 introduced OFDMA, which is a traffic scheduling technique that results in significant speed gains in both crowded and uncrowded environments. Then, Wi-Fi 6E added a tremendous amount of capacity using the 6 GHz band. However, even with scheduled traffic and more capacity, quality of service limitations remained, particularly around latency. Now, as discussed previously, we have MLO in Wi-Fi 7, which allows for rapid switching between two different Wi-Fi bands.

MAPC strategies in Wi-Fi 8, though, are going to take multiple AP management to a whole new level. One anticipated strategy includes coordinated Time Division Multiple Access (c-TDMA), which means APs will take turns transmitting on the same channel during a transmit opportunity (TXOP). INET describes TXOP as an IEEE 802.11 MAC feature that "increases throughput for high priority data by providing contention-free channel access for a period of time."

Alternatively, Spatial Reuse (c-SR) is another MAC strategy that refers to a set of APs transmitting simultaneously on the same channel and during the same TXOP. This strategy, however, is proportional to the network capacity, as the spatial reuse technique is dependent on the number of simultaneous communication that a particular network can handle. Therefore, limited network capacity means limited ability for spatial reuse.

Other coordination techniques include using Dynamic Frequency Selection (DFS) to configure APs in a way that they use non-overlapping channels to minimize interference, configuring APs so that they adjust their transmission power based on proximity to each other, and load balancing or AP configuration that directs clients to connect to the least congested access point.

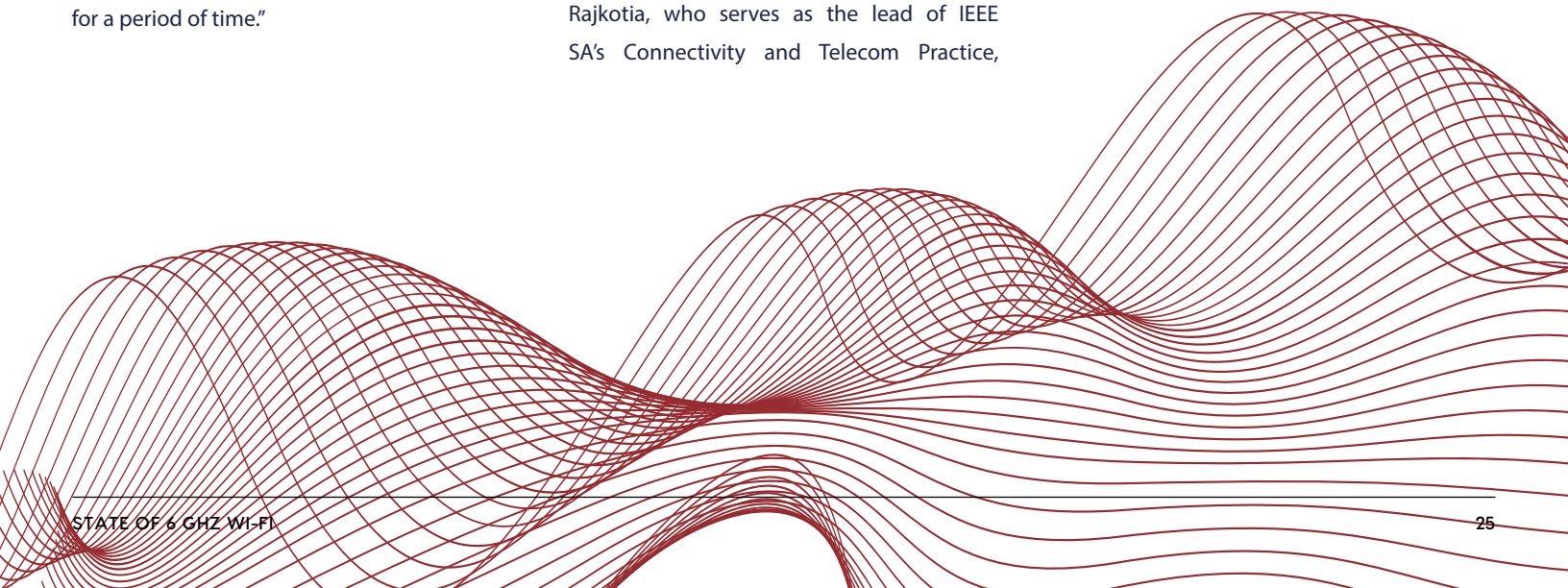
According to Koepp, MAPC is still a "big question mark" for test and measurement in terms of how OEMs will want to test it.

Ambient power communication

Within IEEE, there is a working group called the Ambient Power for WLAN IoT Topic Interest Group (AMP TIG) that is responsible for defining use cases for 802.11 ambient power-enabled IoT devices. Purva Rajkotia, who serves as the lead of IEEE SA's Connectivity and Telecom Practice, told *RCR Wireless News* that ambient power communication is a key area of interest when discussing future Wi-Fi energy saving measures.

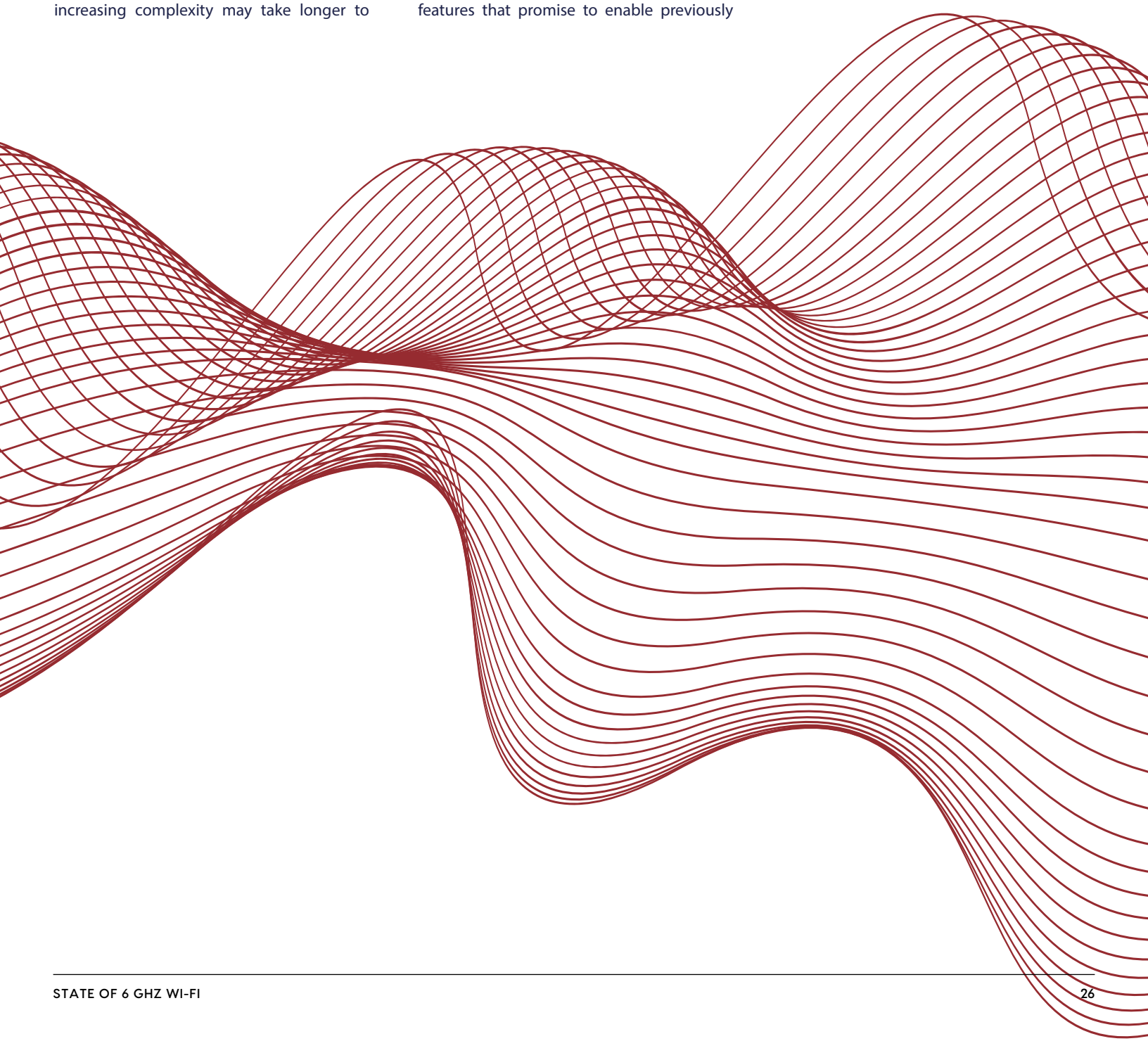
"This particular technology is going to play a very important role because the whole idea of ambient power is that basically you are energy harvesting," he explained. "So, if somebody is walking with a cell phone in their hand, and the hand is moving, energy is being generated by that motion. We want to use that energy to power or charge the device. The concept is that anywhere there is energy, in any form … we should be able to convert that … into a usable energy form. This will increase your energy efficiency."

Other features being considered for Wi-Fi 8 include: distributed Resource Units (dRU), which is designed specifically for low-power indoor (LPI) devices in the 6 GHz band and allows for distribution of allocated tones across a wider bandwidth, reducing the number of tones per MHz, boosting uplink OFDMA transmission power; and the integration of AI and Machine Learning to enhance and improve connectivity.



CONCLUSION

Looking ahead, we can expect discussions of Wi-Fi and cellular convergence to return in earnest as more enterprises look to make the most of these two complementary assets. Also, the picture of Wi-Fi 8 will continue to take shape, while other, more challenging questions around things like global spectrum designation and harmonization and the impact of Wi-Fi's increasing complexity may take longer to resolve. Overall, though, the Wi-Fi industry can feel good about the progress made throughout 2024, whether its global 6 GHz traction or Wi-Fi 7 enterprise adoption. Past conversations have suggested that what makes Wi-Fi attractive — when compared to cellular connectivity, for instance — is that it's simple, it's familiar and it's often "good enough." But, with a host of powerful new features that promise to enable previously impossible consumer and enterprise applications and with even more reliability and determinism on the horizon, the latest generations of Wi-Fi are proving that this technology has much more to offer than simplicity.



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